

1. A stitched in-stack stabilized CPP synthetic spin-valve sensor comprising:
 - a multi-layered pillar type synthetic spin-valve formation, said pillar being defined by a common and uniform lateral cross-section of all included layers and said formation having a longitudinally magnetized ferromagnetic free layer as its uppermost layer;
 - a decoupling layer formed on said free layer, said decoupling layer having the same lateral cross-sectional area as said spin-valve formation;
 - a longitudinal bias layer (LBL) formed on said decoupling layer, said LBL having the same lateral cross-section as said decoupling layer;
 - a multi-layer formation stitched onto said LBL, said formation being characterized by a larger lateral cross-section than said LBL and said formation including:
 - a synthetic exchange tri-layer formation;
 - an antiferromagnetic pinning layer formed on said tri-layer formation;
 - a capping and conducting lead layer formed on said pinning layer; and
 - wherein said tri-layered structure and said LBL are longitudinally magnetized and strongly exchange coupled to said free layer and, thereby, stabilize it.
2. The sensor of claim 1 wherein said synthetic spin-valve formation further comprises:

a seed layer;

an antiferromagnetic pinning layer formed on said seed layer;

a synthetic antiferromagnetic pinned layer formed on said pinning layer, said layer comprising a first (AP1) and a second (AP2) laminated ferromagnetic layer, wherein each said layer is magnetized in opposite directions transversely to the ABS of the sensor, said layers being separated by a non-magnetic layer;

a non-magnetic spacer layer formed on said pinned layer; and

a longitudinally magnetized ferromagnetic free layer formed on said spacer layer.

3. The sensor of claim 2 wherein said first ferromagnetic layer is the lamination CoFe/Cu/CoFe/Cu/CoFe, wherein the CoFe lamina are formed to a thickness between approximately 7 and 15 angstroms and the Cu lamina are formed to a thickness between approximately 1 and 4 angstroms.

4. The sensor of claim 2 wherein said second ferromagnetic layer is the lamination FeCo/Ta/FeCo/Ta/FeCo wherein the FeCo lamina are formed to a thickness between approximately 5 and 15 angstroms and the Ta lamina are formed to a thickness between approximately 0.5 and 3 angstroms.

5. The sensor of Claim 1 wherein said decoupling layer is a tri-layer of non-magnetic materials comprising:

a first layer of Cu of thickness between approximately 4 and 6 angstroms;

- a layer of Ta of thickness between approximately 4 and 15 angstroms;
- a second layer of Cu of thickness between approximately 4 and 6 angstroms.

6. The sensor of Claim 1 wherein said LBL is a layer of FeCo formed to a thickness between approximately 40 and 50 angstroms.

7. The sensor of Claim 1 wherein said free layer is the lamination CoFe/Cu/CoFe/Cu/CoFe wherein the CoFe lamina are formed to a thickness between approximately 7 and 15 angstroms and the Cu lamina are formed to a thickness between approximately 1 and 4 angstroms.

8. The sensor of Claim 1 wherein said synthetic exchange tri-layer formation comprises:

- a first ferromagnetic layer, FM1, formed on said LBL;
- a coupling layer formed on FM1;
- a second ferromagnetic layer, FM2, formed on the coupling layer; and

FM1 and FM2 are longitudinally magnetized in antiparallel directions, FM1 and LBL are magnetized in the same direction and FM2 and said ferromagnetic layer are magnetized in the same direction.

9. The sensor of Claim 8 wherein the magnetic thicknesses of FM1, FM2 and LBL satisfy the relationships: $t(\text{LBL}) + t(\text{FM1}) < t(\text{FM2})$ and $[t(\text{LBL}) + t(\text{FM1})]/t(\text{FM2}) = 70/90$ angstroms of CoFe.

10. The sensor of Claim 8 wherein FM1 is a layer of FeCo formed to a thickness between approximately 5 and 20 angstroms, FM2 is a bilayer of CoFe/FeCo, wherein the CoFe is formed to a thickness between approximately 60 and 90 angstroms and the FeCo is formed to a thickness between approximately 5 and 20 angstroms and the coupling layer is a layer of Ru formed to a thickness between approximately 3 and 5 angstroms.

11. A method of forming a stitched in-stack stabilized CPP synthetic spin-valve sensor comprising:

- forming a multi-layered synthetic spin-valve stack, said stack including a synthetic antiferromagnetic pinned layer and a ferromagnetic free layer;
- forming a decoupling layer on said stack;
- forming a longitudinal bias layer (LBL) on said decoupling layer;
- forming a first capping layer on said LBL;
- magnetizing the synthetic antiferromagnetic pinned layer in a first annealing process;
- magnetizing the free layer in a second annealing process;
- patterning said stack photolithographically, by the removal of laterally disposed portions thereof, to produce a pillar shaped formation having a uniform lateral cross-section;
- forming on said stack, by a stitching process, a synthetic exchange coupling tri-layer;
- forming an antiferromagnetic pinning layer on said tri-layer;

forming a capping and lead layer on said pinning layer;
magnetizing said synthetic tri-layer in a third annealing process.

12. The method of Claim 11 wherein said synthetic spin-valve formation further comprises:

providing a seed layer;

forming an antiferromagnetic pinning layer on said seed layer;

forming a synthetic antiferromagnetic pinned layer on said pinning layer, said layer comprising a first (AP1) and a second (AP2) laminated ferromagnetic layer, wherein each said layer is magnetized in opposite directions transversely to the ABS of the sensor, said layers being separated by a non-magnetic layer;

forming a non-magnetic spacer layer on said pinned layer; and

forming a ferromagnetic free layer on said spacer layer.

13. The method of Claim 12 wherein said first ferromagnetic layer is formed as a lamination CoFe/Cu/CoFe/Cu/CoFe, wherein the CoFe lamina are formed to a thickness between approximately 7 and 15 angstroms and the Cu lamina are formed to a thickness between approximately 1 and 4 angstroms.

14. The method of Claim 12 wherein said second ferromagnetic layer is formed as a lamination FeCo/Ta/FeCo/Ta/FeCo wherein the FeCo lamina are formed to a thickness between approximately 8 and 15 angstroms and the Ta lamina are formed to a thickness between approximately 0.5 and 3 angstroms.

15. The method of Claim 11 wherein said decoupling layer is a tri-layer of non-magnetic materials comprising:
- a first layer of Cu of thickness between approximately 4 and 6 angstroms;
 - a layer of Ta of thickness between approximately 4 and 15 angstroms;
 - a second layer of Cu of thickness between approximately 4 and 6 angstroms.
16. The method of Claim 11 wherein said LBL is formed as a layer of FeCo to a thickness between approximately 40 and 50 angstroms.
17. The method of Claim 11 wherein said first anneal is at a temperature of approximately 280⁰C for approximately 5 hours in a magnetic field of approximately 10 kOe perpendicularly directed to the ABS plane.
18. The method of Claim 11 wherein the second anneal is at approximately 230⁰C for approximately 30 minutes in a longitudinal field of approximately 350 Oe.
19. The method of Claim 11 wherein said free layer is formed as the lamination CoFe/Cu/CoFe/Cu/CoFe wherein the CoFe lamina are formed to a thickness between approximately 7 and 15 angstroms and the Cu lamina are formed to a thickness between approximately 1 and 4 angstroms.

20. The method of Claim 11 wherein said stitching process comprises:
- refilling a region surrounding the patterned pillar with an insulating material;
 - etching away a portion of the refilled material peripherally disposed about the pillar, the etching process also removing said first capping layer and a portion of said LBL and creating, thereby a well of greater cross-sectional area than the pillar and extending laterally beyond the periphery of the pillar;
 - forming a first ferromagnetic layer, FM1, within the well, said layer covering the LBL and extending peripherally beyond it to the periphery of the well;
 - forming a coupling layer on said first ferromagnetic layer;
 - forming a second ferromagnetic layer, FM2 on said coupling layer.
21. The method of Claim 11 wherein said synthetic exchange tri-layer formation is subjected to a low field annealing at approximately 230⁰C for approximately 30 minutes in a magnetic field of approximately 350 Oe whereby FM1 and FM2 are longitudinally magnetized in antiparallel directions, with the magnetizations of FM1 and LBL being in the same direction.
22. The method of Claim 11 wherein the FM1, FM2 and LBL layers are formed so that their magnetic thicknesses satisfy the relationships: $t(\text{LBL}) + t(\text{FM1}) < t(\text{FM2})$ and $[t(\text{LBL}) + t(\text{FM1})] / t(\text{FM2}) = 70/90$ angstroms of CoFe.